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Full Length Research Paper

Nutrient composition, energy value and residual anti-nutritional factors in differently processed breadfruit (*Artocarpus altilis*) meal

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The proximate composition, carbohydrate fraction, minerals and residual anti-nutritional factors in peeled and unpeeled raw, cooked and soaked breadfruit meal were determined. Results indicated that breadfruit meals processed in various ways contained 4.31 - 4.85% crude protein, 5.00 - 5.38% crude fibre, 2.11 - 2.90% ether extract, 68.38 - 69.20% starch and 2.56 - 2.90 ash which can enhance its nutritional status. Residual anti-nutritional factors that were detected in the meals were oxalate (2.70 - 3.30 mg/kg), phytic acid (0.58 - 0.75 g/100 g), tannin (6.06 - 6.70 mg/kg, trypsin inhibitor (0.00 - 21.30 TIU/mg) and haemagglutinin (0.00 - 12.30 HU/mg). The meals also had high gross energy (16.00 - 16.20 Mj/kg) and metabolizable energy (13.01 - 13.74 Mj/Kg). Cooking completely eliminated trypsin inhibitor and haemagglutinin and reduced the concentration of oxalate and tannin while phytic acid was unaffected. Soaking in water reduced (P < 0.05) oxalate, phytic acid, tannin, trypsin inhibitor and haemagglutinin. Peeling, cooking and soaking improved the metabolizable energy of breadfruit meal significantly (P < 0.05). It was concluded that breadfruit meal can be a substitute for maize in poultry diet if properly processed.

Key words: Nutrient composition, energy value, residual anti-nutritional factors, breadfruit meal.

INTRODUCTION

The use of unconventional energy feed resources that are cheaper than maize has been advocated in most tropical countries of the world. Energy feed resources that have been evaluated include cassava, sweet potato and *Colocasia esculenta.* However, there are some energy-rich fruits like bread fruit (*Artocarpus altilis)* that are yet to be thoroughly evaluated. Breadfruit is one of the less-known tropical fruits that have been successfully introduced to the forest zone of the south-western Nigeria. This tree has a great productive ability of 16 - 32 tons/ha (Morton, 1987) and its production usually exceeds demand in the major producing areas. Breadfruit in the fresh form is highly perishable (Amusa et al., 2002) and long term storage for shipment under commercial condition is not feasible at the present stage of technical development (Medlicott, 2002). Its transportation to the urban market centres from rural producing areas is frustrating as more than 70% can be damaged in transit. The storage temperature (12°C) of breadfruit is difficult to achieve under tropical condition, which usually results in heavy loss of produce. Furthermore, breadfruit is not known to be processed unto any acceptable storable food form for man in Nigeria.

Breadfruit could be a potential energy feed resource for non ruminants when properly processed. However, before this can be achieved, there is a need to determine its nutrient composition and energy value as well as elucidating anti-nutritional factors that may be present.

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Abbreviations: PRBFM, Peeled raw breadfruit meal; **URBFM,** unpeeled raw breadfruit meal; **PSBFM,** peeled soaked breadfruit meal; **USBFM,** unpeeled soaked breadfruit meal; **PCBFM,** peeled cooked breadfruit meal; **UCBFM,** unpeeled cooked breadfruit meal; **AME,** apparent metabolizable energy; **ME,** metabolizable energy.

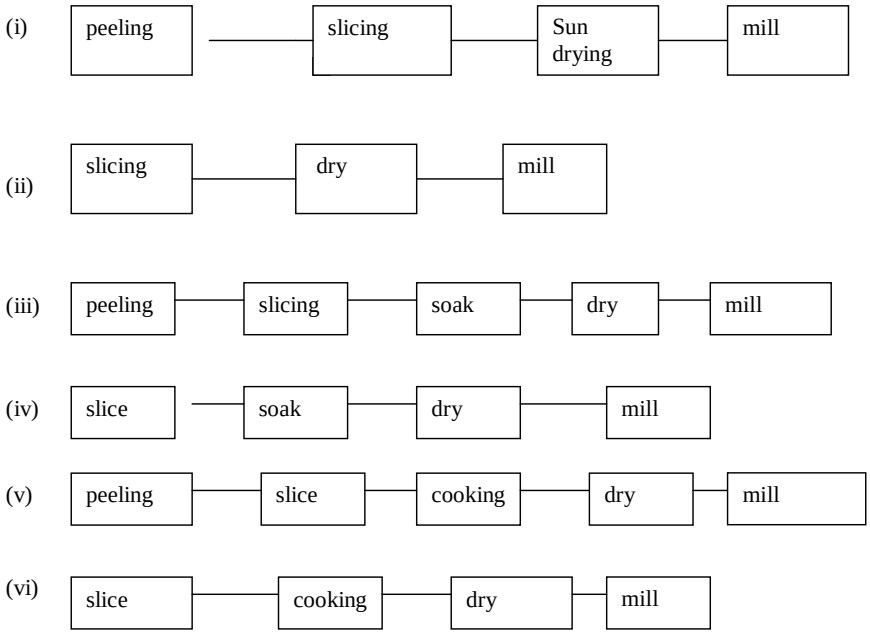

Figure 1. Different ways of preparing breadfruits into meal.

The objective of this study is therefore to provide information on the chemical composition, energy value as well as anti-nutritional factors that may be present in processed breadfruit meal.

MATERIALS AND METHODS

Breadfruit meal preparation

Breadfruits harvested from the same tree on a farm around Ile-Ife, Osun State, Nigeria were prepared into meals in the ways as shown in Figure 1. The samples were sun-dried to about 13% moisture content, pestled to pass through 0.5 mm sieve and stored for analyses. The meals prepared were named peeled raw breadfruit meal (PRBFM), unpeeled raw breadfruit meal (URBFM), peeled soaked breadfruit meal (PSBFM), unpeeled soaked breadfruit meal (USBFM), peeled cooked breadfruit meal (PCBFM) and unpeeled cooked breadfruit meal (UCBFM), respectively.

Energy bioassay

Apparent metabolizable energy (AME) values of the breadfruit meals processed in different ways were determined using 210 day-old Harco Cockerel Chicks. Reference diet was prepared by using 20% glucose while test diets were formulated by substituting 20% glucose in the reference diets with differently processed breadfruit meals. Chromic oxide marker was used at 1% level. All diets were adequate in protein and energy. The composition of the diets is presented in Table 1. Birds were divided into seven groups and the rations assigned to the groups at random with each group replicated four times. The birds were housed in a specially designed fabricated cage for chicks with facility for faecal collection. Birds were fed and watered *ad libitum.* Faecal collection was carried out during the last four days of the 21 day study. The faecal samples were dried in an oven at 60°C for 72 h, bulked and milled to obtain representative samples for chemical analyzes from which the concentration of chromic oxide, dry matter, nitrogen and gross energy were determined. The relative concentration of the chromic oxide in the diets and faeces were used to calculate the AME of the reference and test diets as shown by Hill et al. (1960). The AME were corrected for nitrogen equilibrium (zero retention) using a factor of 8.22 nitrogen retained in the body (Hill and Anderson, 1958). The AME were then computed as follows:

AME = [15.44 x (ME of reference – ME of diet with substituted ingredient)] / 0.02.

Where 15.44 is the experimentally established AME of glucose, 0.20 is the proportion of the substituted breadfruit meal.

Chemical analysis

Breadfruit meal samples were analyzed for proximate composition using the methods of AOAC (1990) chromic oxide marker in the feeds and faeces were determined Spectrophotometric as described by Hill and Anderson (1958). Calcium and iron were determined using a Perkin-Elmer Model 2380 atomic absorption spectro- photometer after wet digestion of the samples. Phosphorus was determined using a spectrophotometic phosphoammonium vanadate reaction described by Ravindran and Sivakanesan (1995).

Tannin was extracted from the samples by the method of Hagerman and Butler (1978). While Folic-Denis method (Hoff and Singleton, 1977) was employed to estimate tannic acid in the extracts. Phytic acid was determined spectrophotometrically after enzymatic hydrolysis with phytase from *Aspergillus ficuum* (March et al., 1995). Total oxalate was determined according to the method described by Yan et al. (2003). Trypsin inhibitor extracts of the breadfruit meal samples were determined using the methods of Chang and de Lumen (1982), while activity was determined by the methods of Kakade et al. (1974). Glucose was estimated by the modified glucose oxidase method described by Meites and Saniel-Banrey (1973) while sucrose and total hexoses were determined by

Table 1. Composition of the reference and test diets used in the apparent metabolizable energy assay (100%).

Diets	Processing methods						
	Reference	PRBFM	URBFM	PSBFM	USBFM	PCBFM	UCBFM
Glucose	20.0	-	-	-	-	-	-
BFM	-	20.0	20.0	20.0	20.0	20.0	20.0
Soybean meal	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Groundnut cake	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Fish meal	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Corn offal	36.4	36.4	36.4	36.4	36.4	36.4	36.4
Oyster shell	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Bone meal	3.0	3.0	3.0	3.0	3.0	3.0	3.0
NaCl	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Methionine	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Premix	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Chromic oxide	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	100	100	100	100	100	100	100

PRBFM = Peeled raw breadfruit meal, URBFM = unpeeled raw breadfruit meal, PSBFM = peeled soaked breadfruit meal, USBFM = unpeeled soaked breadfruit meal, PCBFM = peeled cooked breadfruit meal, and UCBFM = unpeeled cooked breadfruit meal.
*Premix used contained per 35 kg: Vitamin A,12500000 iu; Vitamin D3 2500000 iu; Vitamin E, 40000 mg; Vitamin K, 3,2000 mg; Vitamin B 1,3000 mg; Vitamin B 2,5500 mg; Niacin, 55000; Calcium pantothenate,11500 mg; Vitamin B 6,5000 mg; Vitamin B 12,25 mg; Folic acid,1000 mg; Biotin,80 mg; Cholic chloride, 500000 mg; manganese, 120000 mg; Iron,100000 mg; Zinc, 80000 mg; Copper,8500 mg; Iodine,1500 mg; Cobalt, 300 mg; Selenium,120 mg and Anti-oxidant 120000 mg.

the anthrone procedure (Southgate, 1969). Maltose was estimated by calculating the difference between the total reducing sugars and hexose. Starch analysis was carried out using the methods described by McCleary et al. (1994).

Haemagglutinin extraction and determination of activity was carried out using the methods described by Hankins and Shannon (1978). This was based on the ability to agglutinate trypsinized rabbit erythrocyte. Data collected were subjected to one way analysis of variance using General Linear Model Procedure of SAS (1999) while significant differences between treatment means were determined at $P < 0.05$. Separation of the means was carried out using Duncan's option of the same package.

RESULTS

The proximate composition, energy value and residual anti-nutritional factors in breadfruit meal processed in different ways are presented in Table 2. Breadfruit meal processed in different ways contained 4.31 - 4.85% crude protein, 5.00 - 5.38% crude fibre, 2.11 - 2.90% fat, 2.56 - 2.90% ash and 68.38 - 69.20% starch that can enhance its value as feed resource for poultry. No significant ($P > 0.05$) effect of processing methods was observed in the dry matter; crude protein, ether extract and nitrogen free extract of the meal samples. Significant ($P < 0.05$) difference was however, observed in the ash content of the meals. This could be due to leaching in water during cooking and soaking.

Residual anti-nutritional factors that were detected in the meals were oxalate (2.70 – 3.30 mg/kg), phytic acid (0.58 – 0.75 g/100 g), tannin (6.06 – 6.70 mg/kg), trypsin inhibitors (0.00 – 21.30 TIU/mg) and haemagglutinin (0.00 – 12.30 HU/mg). Processing by cooking and soaking reduced ($P < 0.05$) the concentration of oxalate and tannin while trypsin inhibitors and haemagglutinin were completely eliminated by cooking. Soaking was also effective in reducing phytic acid which was unaffected by cooking.

Processing methods had no significant ($P > 0.05$) effect on gross energy. However, metabolizable energy (ME) was significantly ($P < 0.05$) affected by the processing methods. Peeling significantly ($P < 0.05$) increased the ME value of raw, cooked and soaked breadfruit meal. Also soaked breadfruit meal had higher ($P < 0.05$) ME than cooked breadfruit meal which was also higher ($P < 0.05$) than the raw when in the same form (unpeeled or peeled).

The mineral content and carbohydrate fraction of breadfruit meal processed in different ways is presented in Table 3. No significant ($P > 0.05$) effect of processing methods was observed in the starch, glucose, sucrose, maltose and fructose content of the meals. The concentrations of calcium, phosphorus and iron were however significantly affected by the processing methods. Soaking and cooking significantly reduced these minerals.

Table 2. Mineral content and carbohydrate fraction of differently processed breadfruit meal.

Component	Processing Methods						SEM
	PRBFM	URBFM	PSBFM	USBFM	PCBFM	UCBFM	
Yield (%)	30.20	31.22	28.20	28.60	29.00	29.30	2.7
Ca (g/100g)	0.79[a]	0,80[a]	0.77[b]	0.78[b]	0.74[ab]	0.75[ab]	0.02
Phosphorus (g/100g)	1.88[a]	1.92[a]	1.76[b]	1.78[b]	1.82[ab]	1.79[ab]	0.50
Iron (mg/100g)	7.10[a]	7.40[a]	6.81[b]	6.80[b]	6.82[b]	6.86[b]	0.80
Starch (%)	69.10	69.20	68.40	68.38	68.70	68.90	2.0
Glucose (%)	5.60	5.58	5.32	5.58	5.50	5.78	0.40
Sucrose (%)	6.63	6.82	6.66	6.30	6.45	6.64	0.5
Fructose (%)	7.75	7.66	7.32	7.45	7.46	7.52	0.5
Maltose (%)	0.62	0.60	0.65	0.64	0.61	0.63	0.4

[abc] PRBFM = Peeled raw breadfruit meal; URBFM = unpeeled raw breadfruit meal; PSBFM = peeled soaked breadfruit meal; USBFM = unpeeled soaked breadfruit meal; PCBFM = peeled cooked breadfruit meal; UCBFM = unpeeled cooked breadfruit meal.

Table 3. Chemical composition, energy value and residual anti-nutritional factors in breadfruit meal processed in various ways.

Component	Processing Methods						SEM
	PRBFM	URBFM	PSBFM	USBFM	PCBFM	UCBFM	
Dry Matter (%)	85.27	85.36	85.58	85.48	85.29	85.38	2.00
Crude Protein (%)	4.79	4.63	4.75	4.85	4.63	4.31	0.60
Ether extract (%)	2.90	2.40	2.11	2.64	2.54	2.68	0.50
Crude fiber (%)	5.22	5.00	5.21	5.38	5.20	5.34	0.04
Ash (%)	3.94[a]	3.80[a]	2.70[b]	2.56[b]	3.64[a]	3.54[a]	0.50
N F E (%)	85.4	85.17	84.03	84.27	85.33	85.13	3.00
G E (MJ/kg)	16.10	16.00	16.20	16.10	16.20	16.10	1.50
M E (MJ/Kg)	13.35[d]	13.01[e]	13.74[a]	13.65[b]	13.63[b]	13.50[c]	0.06
Oxalate (m/kg)	3.30[a]	3.20[a]	2.80[b]	2.70[b]	2.60[b]	2.50[b]	0.3
Phytic acid (g/100g)	0.75[a]	0.74[a]	0.59[b]	0.58[b]	0.71[a]	0.78[a]	0.05
Tanin (mg/kg)	6.70[a]	6.60[a]	6.10[b]	6.06[bc]	5.80[bc]	5.60[c]	0.2
Trypsin inhibitor (TIU/mg)	21.30[a]	20.10[a]	8.40[b]	8.70[b]	0.00[c]	0.00[c]	0.6
Haemagglutinin (HU/mg)	11.30[a]	11.90[a]	3.00[b]	3.50[b]	0.00[c]	0.00[c]	0.6

[abc] Means bearing different superscripts along the same row are significantly different ($P < 0.05$).
PRBFM = Peeled raw breadfruit meal; URBFM = unpeeled raw breadfruit meal; PSBFM = peeled soaked breadfruit meal; USBFM = unpeeled soaked breadfruit meal; PCBFM = peeled cooked breadfruit meal; UCBFM = unpeeled cooked breadfruit meal.

DISCUSSION

The protein value obtained for breadfruit meal (4.31 - 4.85%) in this study was slightly lower than the value reported by Ravindran and Sivakanesan (1995) but comparable to the value reported for the mature fruit of Ulu Puou' variety (Wotton and Tumalli, 1984). The protein value obtained for breadfruit meal in this study was almost half that of maize (Ravindran et al., 1996). The fiber content (5.00 – 5.38%) however, almost double the value reported for maize by the same author. The fact that all the meal samples were similar with respect to proximate composition except ash indicates that the nutritive value of breadfruit meal does not depend so much on the processing method.

The detection of anti-nutritional factors in breadfruit meal agree with the report of Uzogara et al. (1987) and Oladunjoye et al. (2004) who had earlier reported the presence of trypsin inhibitors and phytic acid in breadnut and breadfruit meal, respectively. Phytate interacts with

the utilization of proteins and minerals (Prattley et al., 1982; Satterlee and Abdul-Kadir, 1983) and mineral absorption (Davies and Nightingale, 1975) while trypsin inhibitors and haemagglutinin interfere with protein digestion, absorption and utilization in poultry (Oberleas, 1973; Maga, 1982). Tannin also reduces palatability of feed. The improvement observed in the metabolizable energy of differently processed meal can be attributed to processing effects on the fruits which reduced the level of anti-nutritional factors.

The complete elimination of haemagglutinin and trypsin inhibitors observed in cooked breadfruit meal in this study is in line with the report of Emiola et al. (2007) who also observed complete elimination of trypsin inhibitors and haemagglutinin in kidney bean subjected to cooking. However, boiling has been reported to reduce the nutritional value with losses and changes in major nutrients including protein, carbohydrates, minerals and vitamins (FAO, 1990) which explained the decrease that was observed in the mineral content of soaked and cooked meals. Cooking in water also reduce oxalate, tannin and phytic acid in this study. This could be due to degradation or leaching into the water (Lyimo et al., 2006). Soaking in water also reduced the concentration of oxalate, tannin Phytic acid, haemagglutinin and trypsin inhibitors in this study. A similar decrease in hydrocyanic acid was also reported in cassava soaked in water (FAO, 1990). This was ascribed to the breaking of the cells by osmosis and subsequent leaching into the water.

Conclusion

Breadfruit meal contains protein and energy that naturally endow it as a potential feed resource for poultry. Processing by peeling, cooking or soaking in water can be used to reduce anti-nutritional factors in it.

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